PROCESS FOR OPERATING A VIRTUAL SENSOR FOR DETERMINING THE CONDITION OF A TOOL HOLDER ON A TOOL MACHINE; VIRTUAL SENSOR FOR DETERMINING THE CONDITION OF A TOOL HOLDER AND TOOL MACHINE

CROSS REFERENCE OF RELATED APPLICATIONS

[0001] This application claims the benefit of German application DE 10 2019 112 775.0, filed May 15, 2019, and is incorporated by reference herein.

[0002] The invention refers to a process for operating a virtual sensor for determining the condition of a tool holder on a tool machine, and a virtual sensor for determining the condition of a tool holder and a tool machine.

BACKGROUND

[0003] When working with tool machines, workpieces, also known as semi-finished products, are machined by tools on tool machines. Here, the tools are clamped in a tool holder, e.g. a spindle, on the tool machine.

[0004] The radial forces acting on the tool holder (forces perpendicular to the axis of rotation of the tool holder), e.g. on the spindle, during processing of workpieces are dependent on a number of parameters. Restricting these forces to a level which the tool machine can easily withstand is a key criterion when writing machine programs for processing workpieces. Where the limits set for these radial forces are permanently or repeatedly exceeded, this can lead to the tool holder becoming damaged or destroyed.

[0005] On known tool machines, measuring the forces acting on the tool holder directly is laborious, hence on known tool machines the radial forces acting on the tool holder cannot be referred to for controlling the tool machine. Moreover, there exist some known tool machines where the use of additional sensors allows the forces acting on the tool holder to be measured directly.

[0006] This proves to be laborious and cost-intensive.

SUMMARY OF THE INVENTION

[0007] One task of a design example of the invention is to propose a process for operating a virtual sensor, a virtual sensor which can be operated using such a process, and a tool machine which will make it easier to record the forces acting on the tool holder.

[0008] This task is solved by a process for operating a virtual sensor for determining the condition of a tool holder on a tool machine, such as a spindle, and the condition of a tool machine which has at least one tool holder and at least one tool attached or attachable to the tool holder, which allows a workpiece to be processed by running a machine program, and which has at least one control unit comprising at least one sensor using the following steps:

[0009] a. Recording at least one, in particular time-dependent, piece of body data of the workpiece, the tool, the tool holder, and/or at least one drive axle, such as material and/or geometry;

[0010] b. Recording at least one piece of time-dependent room data of the workpiece, the tool, the tool holder, and/or at least one drive axle, such as the position and/or orientation relative to an inert coordinate origin of the tool machine;

[0011] c. Recording at least one piece of time-dependent operating data, such as feed speed, RPM or rotational speed of the tool holder, and/or recording a least one electrical current, in particular one generating a moment, of the tool holder and/or of at least one drive axle;

[0012] d. Recording the time-dependent real total energy intake of one or more steps in the machine program using a least one of the control unit's sensors, and calculating the time-dependent, virtual total energy intake of one or more steps using a virtual simulation of the machine program run by the control unit based on the body data, room data, and operating data recorded; and

[0013] e. Recording or calculating the radial forces acting on the tool holder, at least as the difference between time-dependent real total energy intake and time-dependent virtual total energy intake from the control unit.

[0014] Since the radial forces acting on the tool holder are calculated as the difference between time-dependent real total energy intake and time-dependent virtual total energy intake from the control unit, no additional sensor is provided for on the tool machine. As a result, the tool machine can be developed to be compact and affordable.

[0015] The real total energy intake can be calculated by simply recording the required real electrical power, for example.

[0016] "Virtual" is understood such that no physical object or component is used, rather a calculation based on existing measurement systems and a real-time simulation acts as a virtual sensor.

[0017] Using the process defined by the invention, the forces acting on the tool holder, in particular radial forces, can be measured at any time whilst the machine program is running. This can be performed when a change is made to the machine program or in real time, for example.

[0018] High radial forces occur on the tool holder when the tool holder or the tool attached to the tool holder is driven against an obstacle, e.g. the workpiece. With a properly configured machine program, the material of the workpiece exposed to the tool is ablated by the rotation of the tool, whereby the radial forces acting on the tool holder are minimal.

[0019] When further developing the process, therefore, it proves advantageous for the time-dependent virtual energy intake to comprise at least the sum of the calculated, time-dependent, virtual energy intake of the workpiece holder when idling, in particular when not processing the workpiece, across one or more steps of the machine program cycle, and the time-dependent, virtual energy intake of processing a workpiece across one or more steps of the machine program cycle.

[0020] In such case, the machine program may be observed separately both during idling and during workpiece processing.

[0021] Furthermore, in developing the latter process further it is intended that the time-dependent, virtual energy intake during idling across one or more steps of the machine program cycle can be calculated using the required mechanical energy of at least one idling drive axle, in particular without workpiece processing, or from at least one machine efficiency level for mechanical energy, and/or that the time-dependent virtual energy intake during idling can be calcu-